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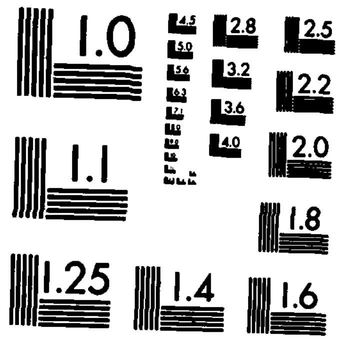

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RESIN ADAPTATION OF RADICULAR DENTIN TUBULES AFTER ENDODONTIC INSTRUMENTATION AND ACID ETCHING

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ABSTRACT

The scanning electron microscope and extracted human teeth were used to evaluate how well a low viscosity resin adapted to the radicular dentin tubules after the root canals had been endodontically instrumented and etched with an acid. Examination of the specimens revealed the acid removed the smeared layer and that the resin could penetrate and adapt well to the exposed, patent dentin tubules. These findings may be clinically applicable in root canal therapy.

Despite the high success rate of current endodontic techniques, several major, persistent problems continue unsolved. Among these are: the failure of current debridement techniques to completely remove tissue debris; failure of current instrumentation techniques to prepare the entire canal wall; residual bacteria left in the canal after instrumentation; the effect of the smeared layer resulting from instrumentation and obtaining an effective seal for the treated canal.[1,2] The development of a safe, effective root canal treatment technique, which would be easier to use and diminish or eliminate the problems associated with traditional root canal treatment techniques, is desirable. New techniques involving acid etching of teeth have become widely used in recent years.[3] Also, newer, improved dental materials are continually being made available. Experimentation with new techniques and materials may produce a more ideal way to perform root canal treatment.

This investigation used a scanning electron microscope (SEM) to evaluate the adaptation of a low viscosity, dental resin to the radicular dentin tubules after the root canal walls had been endodontically instrumented and etched with an acid.

MATERIALS AND METHODS

Ten extracted, single-rooted, human teeth which had been stored in 2% glutaraldehyde were used in the study. The crowns were amputated at the level of the cemento-enamel junction and routine endodontic instrumentation was performed in the root canals using sodium hypochlorite (2.5%) as the intracanal irrigant. After completion of the

endodontic instrumentation, the canals were flushed with 25 ml. of sterile saline and dried with paper points and an air syringe. The canals were then etched with orthophosphoric acid (37%) for three minutes. Previous studies in this laboratory had shown this etching procedure effectively removed the smeared layer caused by instrumentation and left a very clean canal wall with exposed, patent dentin tubules. After etching, the canals were again flushed with 25 ml. of sterile saline and dried with paper points and an air syringe. Next, a low viscosity resin* was mixed according to the manufacturer's directions and placed into the canal with an applicator brush and endodontic spreader until the canal was completely filled. Great care was taken to minimize air-bubble formation during manipulation and placement of the resin. The resin was allowed to set for one day at 37°C in 100% humidity. The teeth were then longitudinally grooved and split in half. In each case, upon gross inspection, the entire resin core, which had filled the canal space, remained attached to one of the fractured halves. Both halves of each split tooth were mounted on a single stub, canal side up, and prepared for SEM evaluation. A SEM** was used to evalute the exposed surface of the canal wall and the resin core which had formed the canal wall-resin core interface before the tooth was split. The specimens were examined with a SEM at 20kV using magnifications of between 10 and 10,000 times.

*Johnson & Johnson Dental Restorative Bonding Agent, Johnson & Johnson Dental Products Company, 20 Lake Drive, East Windsor, New Jersey 08520
**1000-A, Advanced Metal Research Corporation, 1960 Middlesex Turnpike, Bedford, MA 01730

RESULTS

Examination of the canal walls showed the etching procedure effectively removed the smeared layer and left a very clean canal wall with patent dentin tubules (Fig 1). In addition, resin plugs were seen in most of the dentin tubules (Fig 1). These resin plugs were usually short and stump-like, typically 1-4 μ in length. However, longer plugs, varying in lengths up to 10-15 μ, were also seen protruding from some orifices (Fig 2). A small gap was consistently seen between the resin plug and the adjacent wall of the dentin tubule (Fig 3). This gap was usually about 0.5 μ or less and seldom larger than 1 μ. No resin plug could be seen in some of the dentin tubules, and these tubules appeared patent and empty (Figs 1, 2 and 3). Occasionally, larger, wafer-like pieces of resin were seen on the canal wall (Fig 4). Examination of the periphery of these larger pieces showed that they were confluent with the resin plugs in the dentin tubules below.

Examination of the resin cores revealed numerous resin projections extending from their surfaces (Fig 5). These projections were typically short and stump-like. However, longer ones, varying in lengths up to 25 μ, were occasionally seen. The projections on the resin cores seemed to correspond in size and distribution to the resin plugs seen in the dentin tubules on the canal wall. Some spherical voids were also seen on the surfaces of the resin cores (Fig 6). These voids varied in size and appeared randomly distributed.

The surface of the voids was smooth and contained no resin projections.

DISCUSSION

The vast majority of the resin plugs in the dentin tubules and the resin projections on the resin cores were short, usually 1-4 μ in length. These resin plugs and projections were thought to be the fractured parts of resin filaments that had originally extended outward from the surface of the resin core into the dentin tubules before being fractured by the splitting of the tooth. The short projections on the resin cores were thought to be the bases of the resin filaments and the resin plugs in the dentin tubules the most medial part of the filaments which had been fractured off from the bases. The findings indicated that the vast majority of the resin filaments fractured at, or very near, the level of the canal wall-resin core interface. The longer resin plugs, seen protruding from the dentin tubules were thought to be resin filaments that had been partially pulled out of their tubules for varying distances before fracturing from their bases as the tooth was split. The longer projections, occasionally seen on the resin cores, were thought to result because some of the filaments fractured at varying levels down inside the dentin tubules as the tooth was split, rather than at the canal wall-resin core interface. The part of the filament medial to the fracture remained attached to its base on the resin core and was pulled from the dentin tubule as the core was separated from the canal wall. This would account for the longer resin projections seen on the

resin core surfaces as well as the corresponding number of dentin tubules which appeared empty on the canal wall preparations. The above findings suggest that the low viscosity, dental resin can penetrate and adapt well to exposed, patent dentin tubules.

A small gap was consistently seen between the resin plug and the adjacent wall of the dentin tubule. This gap was typically 0.5 μ or less and seldom as large as 1 μ. It could not be determined if this gap was caused by shrinkage of the resin, splitting of the tooth, or the vacuums used during specimen preparation and examination.

The larger, wafer-like pieces of resin, occasionally seen on the canal wall, were thought to result from fracture within the resin core itself, rather than at the canal wall-resin core interface. Examination of the edges of these larger resin pieces showed that they were confluent with the resin filaments in the dentin tubules below. The fact that the fracture occurred within resin mass compromising the core and not at the canal wall-resin core interface suggests the bond between the resin filaments in the dentin tubules and the surface of the resin core is quite strong.

The variable-sized, randomly distributed, spherical voids, which were noticed in some areas of the resin core surface, were presumed to be caused by entrapped air bubbles. These air bubbles apparently prevented the resin from contacting the canal wall and penetrating the patent dentin tubules since the resin surface of the voids was recessed, smooth and without resin projects.

This technique, or some modification, may have clinical application in the preparation, obturation, and sealing of root canal spaces. However, additional experimentation is obviously necessary to evaluate the effects on the supporting connective tissues of any acid or resin that may escape from the canal space, as well as the sealing ability of the resin cores. While the resin did reliably penetrate the patent dentin tubules everywhere the resin contacted the canal wall, the resin plugs in the dentin tubules consistently displayed a small gap between the plug and the adjacent wall of the dentin tubule. The significance of this gap around the resin plugs in the dentin tubules, the air bubbles at the canal wall-resin core interface, and any potential gap at the canal wall-resin core interface must be evaluated by leakage studies. Additional studies are planned at this Institute to evaluate the sealing ability of this experimental technique for obturating root canal spaces.

SUMMARY AND CONCLUSIONS

A scanning electron microscope and extracted human teeth were used to evaluate the adaptation of a low viscosity dental resin to the radicular dentin tubules after the root canal walls had been endodontically instrumented and acid-etched. The following observations were made:

- Etching the canals with orthophosphoric acid (37%) for three minutes effectively removed the smeared layer and left a clean canal wall with exposed, patent dentin tubules.

- The low viscosity dental resin can penetrate and adapt well to the exposed, patent dentin tubules.
- A small gap, typically 0.5 μ or less, was consistently seen between the resin plug in the dentin tubule and the wall of the dentin tubule.
- Air bubbles prevented the resin from contacting the canal walls in some areas.

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FIGURE LEGEND

Fig 1 The canal wall is clean and free of a smeared layer. Most of the exposed dentin tubules are filled with resin plugs, however, some appear empty and patent. Original magnification of 3760.

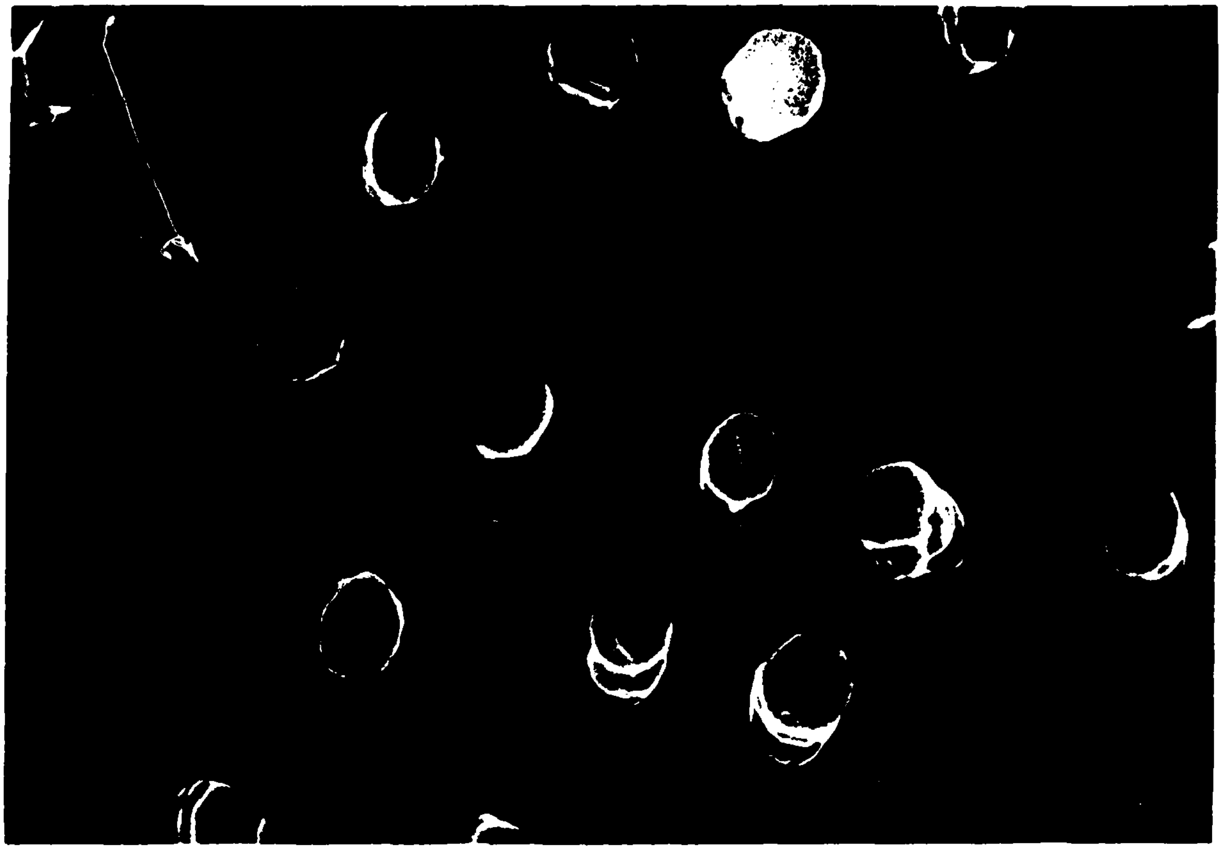
Fig 2 Most of the resin plugs were short and stump-like, usually 1-4 μ long. However, longer plugs up to 15 μ in length were also seen. Original magnification of 1800.

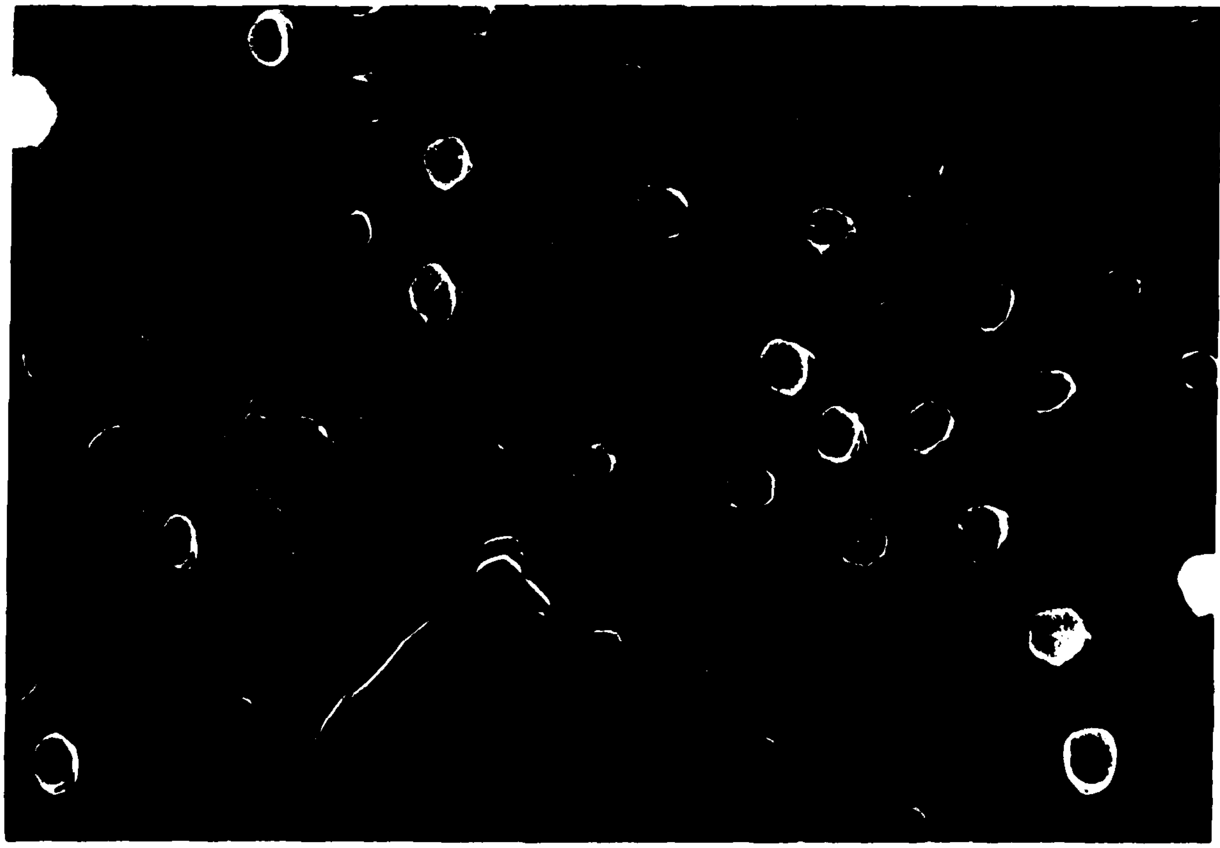
Fig 3 A small gap, usually 0.5 μ or less and seldom larger than 0.1 μ, was consistently seen between the resin plug and the wall of the dentin tubule. Original magnification of 8000.

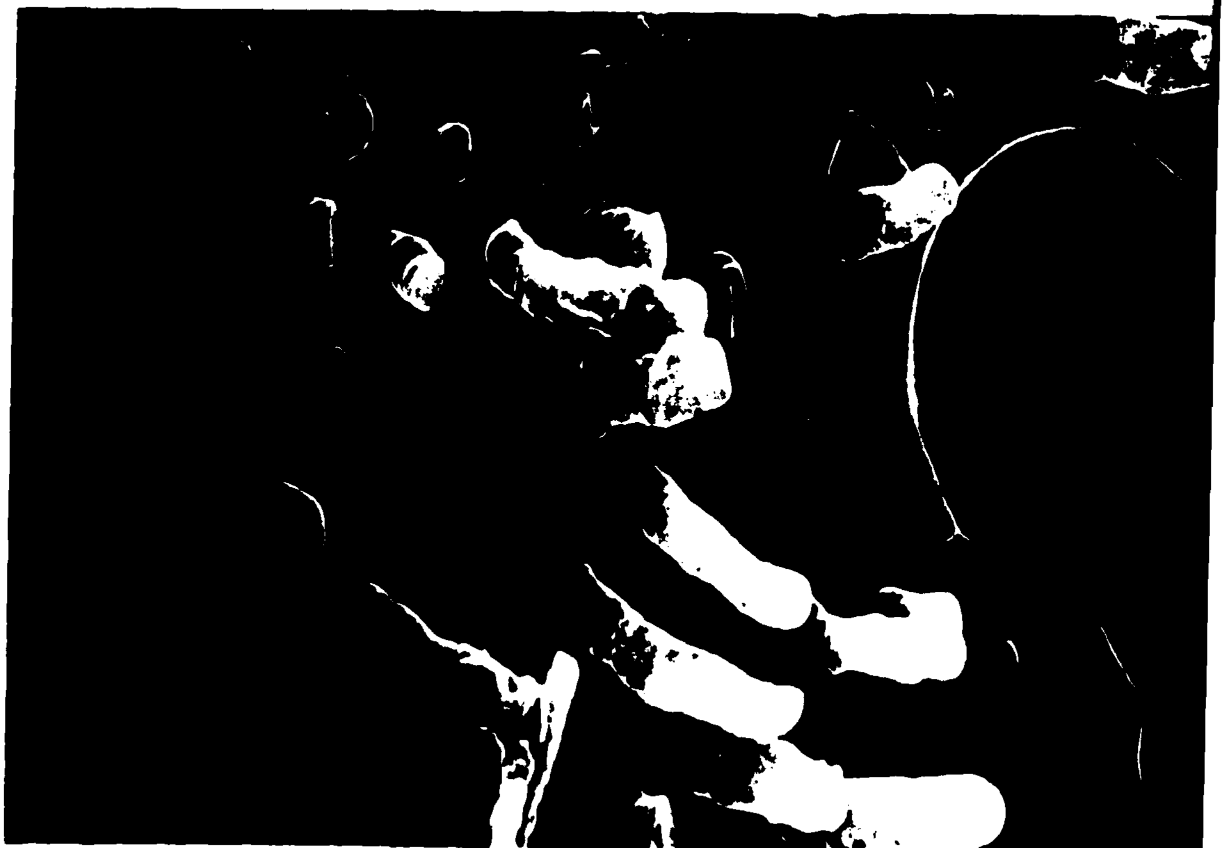
Fig 4 Some larger, wafer-like pieces of resin were also seen on the canal walls. The edges of these larger pieces were confluent with the resin plugs in the tubules below. Original magnification of 1960.

Fig 5 The surface of the resin cores displayed numerous resin projections. Most were short and stump-like, however, some were as long as 25 μ. Original magnification of 1560.

Fig 6 Spherical voids were also seen on the surface of the resin cores. The surface of the voids was smooth and without resin projections. Original magnification of 1520.







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